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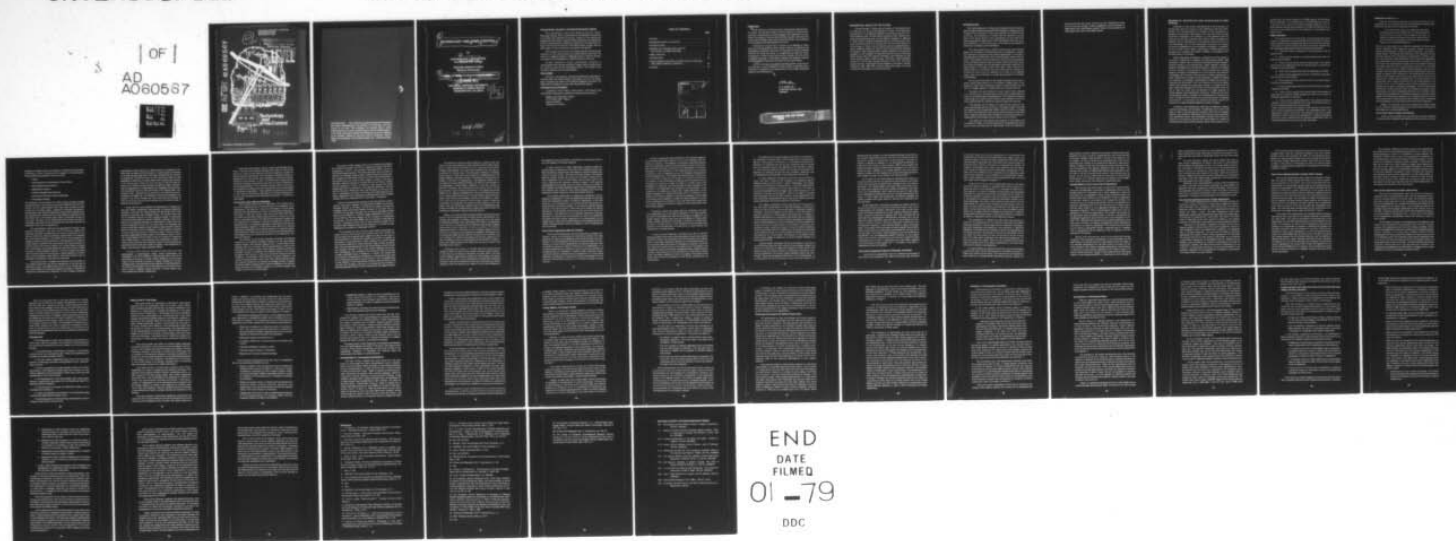
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About the cover: Although this monograph deals with its present and future manifestations, the problem of technology and arms control is not new. The crossbow, for example, was a major advancement in the weapons technology of the early Middle Ages. In 1139, in fact, the second Lateran Council banned use of the crossbow as an invention "hateful to God and unfit for Christians." See Sir Ralph Payne-Gallwey, *The Crossbow* (New York: Bramhall House, 1958).

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TECHNOLOGY AND ARMS CONTROL

by

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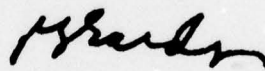
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FOREWORD

Arms control is a vital and highly controversial national security issue. Among other factors, technological considerations seriously complicate the development and negotiation of arms control proposals. Colonel Stukel's ^{THE} monograph examines the interaction between arms control and technology, with emphasis on the research and development function.

The author argues that it usually is not feasible to reach arms control agreements which place controls on research and development activities, and that it is imprudent to place unilateral controls on these activities. In suggesting the need for closer integration of arms control and security policies, he calls for an increased exchange of information between the defense research and development community and arms control specialists.

In this monograph, Colonel Stukel makes a significant contribution to the dialogue on arms control in general and in particular to questions of its relationship to technology, especially research and development.



R. G. GARD, JR.
Lieutenant General, USA
President

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BIOGRAPHICAL SKETCH OF THE AUTHOR

Colonel Donald J. Stukel was a student at The National War College and an Associate Research Fellow in the Research Directorate of the National Defense University during the 1977-1978 academic year. Colonel Stukel received a BS in Military Science and Engineering from the US Military Academy in 1960 and in 1962 an MS in Electrical Engineering from the University of Illinois. He earned his Ph.D in Physics from the Air Force Institute of Technology in 1969. Colonel Stukel's previous assignments include: Assistant Deputy for Control and Communication Systems at Hanscom AFB, Massachusetts; Special Assistant to the Deputy Assistant to the President for National Security Council Planning, White House, 1973-1974; Special Assistant to the President for National Security Affairs, White House, 1972-1973; Project Manager, Avionics, F-15 Project, Wright-Patterson AFB, 1971-1972; and Deputy Director, Solid State Physics Research Laboratory, Wright-Patterson AFB, 1969-1970. Colonel Stukel has written numerous articles with emphasis on solid-state physics.

INTRODUCTION

The rapid advances in military technology during this century have brought qualitative and quantitative changes in weaponry which threaten the existence of man as a species. As a result of this condition, the prevention of nuclear war has become a primary task of the governments of the superpowers. At the same time, these governments seek to gain what advantages there may be in the possession of military forces, including the advantage of deterrence of attacks upon themselves.

The rapid advances in military technology have radically altered the concepts of national security and supplied a compelling incentive for pursuing arms control agreements. In the past, it was generally accepted that more armed strength meant more security. This equation may no longer be valid for the superpowers, which possess arsenals able to destroy each other many times over. More armaments do not necessarily guarantee more security. Depending on the type of arms, they may, in fact, have an opposite effect by providing the other party with an incentive to initiate the use of nuclear weapons in a crisis or to undertake major new arms programs to avoid being placed at a strategic disadvantage.

Arms control has come to be widely accepted as one way in which nations seek security in an uncertain nuclear world. It has become a major and continuing concern of governments and, as such, an integral aspect of foreign policy and national security.

Ironically, this new impetus for arms control which resulted from advances in technology is itself being challenged by continuing technological developments. This interaction between technology and arms control poses many problems as well as some opportunities for mankind's quest for peace and security.

The objective of this paper is to explore this interaction between technology and arms control. The paper seeks to provide the research and development (R&D) community with an insight into the critical elements of the arms control process. At the same time, it seeks to provide those involved in arms control a better understanding of technology and its impact on arms control.

The paper will first discuss the meaning of technology and its relation to R&D. It will then examine the characteristics of the arms control process and of technology. From this discussion,

conclusions will be drawn concerning the interaction of arms control and technology. Finally, suggestions will be offered on steps which the United States needs to take to have coherent and compatible arms control and R&D policies.

MEANING OF TECHNOLOGY AND ITS RELATION TO ARMS CONTROL

Important to the overall understanding of the interaction of technology and arms control is the meaning of the word technology. It is the application of science to the manufacture of products and services. Technology is the know-how that converts scientific knowledge into products. It is the specific know-how required to define a product that fulfills a need, to design the product, and to manufacture it. The product is the end result of this technology, but it is not technology. A product is an object such as an integrated circuit, an airplane, a computer, or software. In the context of this paper, technology is neither science nor products, nor hardware, but rather a system of knowledge which converts theory to hardware.¹

When discussing technology, a related term which needs to be clearly understood is research and development (R&D). R&D activities, in reality, form a continuum consisting of basic research, applied research, and development. Basic research consists of original investigations for the advancement of scientific knowledge without specific commercial or military objectives. Applied research consists of investigations to try to discover new scientific knowledge with specific commercial or military applications in mind. Development consists of the translation of research findings into products or processes. Development includes the process of engineering refinement from the laboratory to the final elaborations that precede and accompany testing. It includes what has been called technological drift, which are the processes which do not, or need not, result from the decisions of higher authority or formal research and development machinery. These are the minor improvements made in systems and components to overcome the minor problems which appear during development, marketing, deployment, or servicing, but whose cumulative impact can amount to or make possible substantial system changes.²

Research and development has three fundamental outputs: science, technology, and products. Traditionally, arms control has been primarily concerned with products which are the weapon systems. The inability to effectively control the products, especially their qualitative nature, has increasingly focused arms control attention on controlling science and technology as a means of controlling the nature of the products. Hence, arms control is con-

cerned with the entire spectrum of R&D outputs. On the other hand, technology is an integral part of the R&D spectrum since it is derived from science and makes possible products. It is for these reasons that the entire spectrum of R&D activities will be of concern in the examination of the interaction of technology and arms control.

ARMS CONTROL

To understand the interaction of technology and arms control, it is essential to have an insight into the nature of the arms control process and the agreements which result from the process. In this section it will be shown that the arms control process and the resulting agreements have the following characteristics:

1. The arms control objectives of the participants may be asymmetrical.
2. Arms control considers the asymmetries that exist between the participants.
3. Arms control issues must be negotiable. This implies both a forum for negotiation and an outcome which is mutually acceptable to the participants.
4. Arms control agreements must be adequately verifiable.
5. Arms control agreements may be unilaterally terminated at any time by any participant.
6. The content and time frame of future arms control agreements are unpredictable.
7. Arms control agreements are arrived at through a lengthy negotiation process.
8. Arms control agreements which affect the interests of allies take into account these interests and take a form which is generally acceptable to the allies.
9. Arms control agreements take into account actual or potential rivals of the participants and must not jeopardize the security of the participants vis-a-vis the rivals.

These characteristics are inherent in the process of arriving at arms control agreements between the superpowers and in the agreements which result from this process. They have all been observed in recent arms control negotiations. To better understand the arms control process and the resulting agreements, each of these characteristics will now be briefly discussed.

Objectives of Arms Control

The arms control objectives of the participants may be asymmetrical. The US Arms Control and Disarmament Agency has stated the US arms control objectives as follows:

The paramount goal is to make war less likely, and above all, to avoid nuclear war. Of course, US arms control policy pursues other objectives as well: to reduce the destructiveness of wars when wars do occur and to reduce the expenditure of human and economic resources for military preparations.³

We do not have access to a definitive statement of Soviet arms control objectives. Their objectives, however, appear to involve a variety of technological, military, political, economic, and psychological factors. The Soviets are believed to have objective motives which are derived from perceptions of likely gains in military, political, and economic areas; subjective motives which are generated by uncertainties and concerns about their ability to prevail in an arms race; and manipulative motives which are aimed at creating favorable political and psychological conditions in the West relevant to arms control. While Soviet objectives may be more complex than the stated objectives of the United States, there is no reason to believe that a reduction in the likelihood of war and the effects of war should war occur are not major Soviet arms control objectives. These shared objectives in no way eliminate the possibility that a major motivation of the United States or the Soviet Union in the ongoing arms control negotiation is to perpetuate or gain a strategic advantage.⁴ The fact that Soviet literature on military doctrine does not accept the concept of strategic parity, but rather emphasizes the need for the Soviet Union to gain both qualitative and quantitative superiority over the United States, has raised some questions as to whether the latter may be the predominant Soviet objective and creates doubt concerning the compatibility of the US and Soviet arms control objectives.

Clearly, the national arms control objectives, whether stated or not, will be a controlling factor in the arms control process and will shape any resulting agreements.

Arms Control Must Consider Asymmetries

Arms control considers the asymmetries that exist between the participants. National approaches to arms control, like other

elements of foreign policy, are based on a variety of factors which are seldom, if ever, symmetric with respect to the participants. These potentially asymmetric factors include:

- history
- value systems and perceptions of each other
- past statements and policies
- geopolitical situation
- military strategies and doctrines
- existing and planned military capabilities
- technological bases

The approach to arms control of a nation which has been invaded numerous times in its history may be quite different from that of a nation, like the United States, which has never suffered a major invasion by a foreign power. Likewise the attitudes, perceptions, and policies of two nations possessing diametrically opposed political and economic systems will be quite different, especially when one nation has, in the recent past, openly proclaimed its goal of "burying" the other. All of these factors will impact the level of verification required to have confidence that the other side can be expected to live up to the agreement.

The asymmetries resulting from geographical location must also be considered in the arms control process. Location will influence, although not determine, the choice of allies and is very likely to offer quite different strategic opportunities. For example, the continental location of the Soviet Union has conditioned its strategic doctrine and has allowed for the deployment of medium-range weapon systems that could exploit the close proximity of nations whose territorial integrity the United States considers vital.⁵ Conversely, the United States has used the territory of allies to station forward-based systems. This has caused the Soviet Union to push hard for the inclusion of these systems in the Strategic Arms Limitation Talks (SALT). Other asymmetries such as population distributions must also be considered.

The asymmetry in strategy and doctrine is most evident in the differing American and Soviet approaches to the dilemma of deterrence versus war-fighting and survival in the nuclear age. In the United States, the prevailing tendency has been to resolve this dilemma by maintaining a capability to inflict massive retaliatory

punishment on the society of an attacker and by conceding to the other side the ability to do the same. In recent years this reliance on mutual assured destruction has been coupled with the concept of sufficiency. The Soviet Union, on the other hand, while no less dedicated to deterring a nuclear attack, has long seemed reluctant to tie its security solely to the concept of mutual assured destruction. Rather, Soviet strategic thought has been characterized by resistance to a "deterrence-only" strategic posture and by the persistent doctrine that the Soviet Union should seek "balanced forces," backed by an extensive civil defense system, enabling it to wage war, limit damage to the Soviet homeland, and prevail in an all-out nuclear war, thus improving the chances of Soviet national survival and emergence as a major power if deterrence should fail.⁶

Arms control must address the differences in existing and planned military capabilities. Asymmetries in existing capabilities are seen in the way the United States and the Soviet Union have chosen to structure their strategic forces. The Soviet choice has led to strategic delivery forces consisting largely of silo-based intercontinental ballistic missiles (ICBM's). Likewise, most of the Soviet throw-weight potential is concentrated in these fixed and hence targetable forces. On the other hand, US warheads and bombs have been spread widely among diverse systems, leaving about 25 percent of the US capability in fixed systems, compared to more than 60 percent in the Soviet case.⁷ Asymmetries in planned capabilities are also evident in the different ways in which the United States and the Soviet Union are moving to modernize their ICBM forces. In the American case, emphasis is placed on improving the accuracy and command control of existing systems, while the Soviet Union has chosen to deploy a new generation of large, more accurate, higher payload missiles.

Finally, arms control indirectly must deal with the asymmetries in technological bases. These asymmetries are manifested in terms of systems in development where one of the participants has a lead in a given military capability, such as long-range cruise missiles, because of certain strengths in its technological base. Asymmetries are also reflected in the differences in the levels of technology in the United States and the Soviet Union, which result in different weapon systems or similar weapon systems possessing different capabilities.

These asymmetric factors, which contain considerable uncertainty, interact and hopefully balance each other to provide the basis for compromise based on political judgments. Except for specific military capabilities, they are seldom expressed directly in agreements but they are the main obstacles to overcome if agreements are to be reached. In SALT, the difficulties in balancing the US-Soviet strategic asymmetries have been the major obstacles to reaching agreements. In the multipolar nuclear world of the future, the problems of dealing with the asymmetries will be exacerbated in multilateral negotiations. These additional problems are evident in the ongoing multilateral negotiations on Mutual Reduction of Forces and Armaments and Associated Measures in Central Europe (MFR).

Arms Control Issues Must be Negotiable

Arms control issues must be negotiable. This implies both a forum for negotiation and an outcome which is acceptable to the participants. The need for a forum is self-evident, but the establishment and maintenance of a forum is a significant challenge. At this point in time, two forums exist: SALT and MFR. Both SALT and MFR are directed toward placing limits on forces, but they differ in participants and in the way the boundaries for agreement are defined. As a functional or mission-bounded arms control undertaking, SALT is a bilateral negotiation organized to limit US and Soviet strategic weapons. On the other hand, MFR is an alliance negotiation organized to limit tactical weapons in a specific region, Central Europe. These two forums are built around the assumption that weapons can be functionally divided into two categories: strategic and tactical.

In practice, the boundary between strategic and tactical weapons is not precise. Strategic weapons can be used against tactical targets, while tactical weapons can, in some cases, serve strategic roles. For countries that are geographically close to their adversaries, shorter-range nuclear delivery systems constitute a strategic threat. For example, the strategic forces of the United Kingdom and France—submarine launched ballistic missiles (SLBM's), intermediate range ballistic missiles (IRBM's), and medium-range bombers—are of less than intercontinental range, but must be viewed by the Soviets as strategic threats. Likewise, the Soviet medium-range ballistic missiles (MRBM's), and medium-range bombers are strategic threats to the United Kingdom and France, but not to the United States.

The issue of what weapons are to be considered candidates for limitations has been a source of dispute throughout the SALT negotiations. In SALT I this problem manifested itself in terms of US forward-based systems. The Soviet approach was to advance a definition of strategic systems which would include all nuclear systems capable of striking the territory of either the United States or the Soviet Union by virtue of their range or location. This was a definition carefully tailored to include US, but not Soviet, tactical nuclear weapons in SALT limitations, even though the United States sees both as elements in the regional balances in Europe and the Far East.⁸ While this issue was set aside in arriving at the SALT I agreements, and also in arriving at the Vladivostok accord, Soviet negotiators have reportedly emphasized that forward-based systems will be an important item on any SALT III agenda.⁹

While US forward-based systems have stirred Soviet concern, another "grey area" weapon, the Soviet SS-20 IRBM, has recently attracted interest in the West. The SS-20 will clearly increase the strategic threat confronting Western Europe. At the same time, if the SS-20, as has been reported, can be quickly upgraded to ICBM status by the addition of another stage (essentially converting it into an SS-16), then this weapon will be a subject of considerable US concern. The fact that IRBM's are not included in negotiations at SALT I (because of their lack of intercontinental range) nor at the MFR talks (because they are not deployed in Central Europe) highlights the problem of inadequate forums.¹⁰

The problem for the future is that military technology no longer insures that function will coincide with form. While new technologies are allowing older systems to take on new roles, a new generation of advanced missiles and aircraft is capable of performing a wide spectrum of roles, ranging from shorter-range nonnuclear missions to intercontinental range nuclear bombardment. The planned deployment by the United States of both tactical and strategic versions of the cruise missile highlights this problem. Increasingly, then, strategic arms cannot be said to comprise a readily definable class of weaponry. In theory, this means that the functional categorization of weaponry will have declining utility as an organizing principle for arms control. Thus, the deployment of new classes of multi-role delivery vehicles, able to perform both tactical and strategic missions, will compound the problem of defining adequate forums in which to deal with the weapon system.

An additional concern which arises as a result of the new class of multi-role weapons is that controls—which seem necessary to insure control in the SALT forum—may limit not only their strategic effectiveness, but could also influence how they can be exploited for tactical roles. Thus decisions reflecting a strategic preoccupation could well have important consequences for the theater balance in Europe and Asia. The severity of this problem is evident in the SALT II negotiations in the apparent inability to incorporate the Soviet Backfire bomber and the US cruise missile in the agreement. United States attempts to limit the number of Backfire bombers were resisted by the Soviet Union on the grounds that it was not being procured for use against the United States but for regional contingencies. The cruise missile issue was more complicated because the United States was planning to deploy both tactical and strategic versions of the system. In addition, options for European force modernization might be preempted unacceptably by limiting cruise missiles, or for that matter, any new technology. Neither side in the negotiations was willing to accept the consequences of using the vehicle of SALT to foreclose on potentially important tactical options.

Hence, it is clear that technology threatens the existing arms control forums because they are built around assumptions concerning the character of military technology that is on the verge of becoming obsolete. New technology will make it progressively more difficult to disassociate the bilateral superpower strategic relationship from regional military concerns. The task of determining what is, and what is not, a strategic weapon and the difficulty of isolating the superpower strategic relationship from the wider East-West nuclear balance will grow more important and more difficult as military technology and the grey areas grow in size. The ability of the two superpowers and their allies to come to terms with these problems will determine the future of SALT and East-West arms control.¹¹

Looking to the future, it is clear that new forums will be needed to take into account the nuclear arsenals of other nations. In the case of the People's Republic of China (PRC), this may involve trilateral negotiations among the United States, the Soviet Union, and the PRC. In such negotiations, the distinction between strategic and tactical weapons would lose meaning since Soviet weapons which are tactical with respect to the United States will

be strategic as far as the PRC is concerned. Of course the same is true with respect to Chinese weapons.

If arms control is to make meaningful progress towards its primary goals of making war less likely and avoiding nuclear war, then the growing class of grey area weapons (United Kingdom and French nuclear forces, US forward-based systems, and Soviet regional nuclear forces) will have to be included in some forum. This is essential if for no other reason than at some point in the future, assuming the reduction process is begun, it will become unacceptable to the Soviet Union to further reduce the number of their strategic warheads targetable against the United States, when they become only a fraction of the total warheads which could be delivered to Soviet targets by US forward-based systems.

The ultimate requirement for reaching an agreement, and for keeping an agreement, is that the agreement provides an outcome which the participants prefer to having no agreement. In the final analysis, the acceptability of an arms control agreement is determined by political decision of the relevant decisionmaking bodies of the participants. These decisions weigh the relative desirability of the situation which would exist with and without the agreement. This decision will be strongly influenced, although perhaps not determined, by the extent to which the agreement promotes the arms control objectives of the participants; by the impact it has, in the view of the participants, on the relative balance of power of the participants; and by the degree to which the agreement can be verified.

Arms Control Agreements Must Be Verifiable

Arms control agreements must be adequately verifiable. Verification, which is the attempt to determine whether the other parties to an arms control agreement are complying with their obligations, is a critical element of the arms control process. The verification of arms control agreements has several purposes. First, verification serves to detect violations of an agreement, or to provide evidence that violations may be occurring. Second, by increasing the risk of detection, it helps to deter violations. Finally, evidence which indicates that an agreement is in fact being observed, contributes to mutual trust among the parties, and creates an atmosphere conducive to further progress in arms control.¹²

Almost no agreement that proposes to limit modern weapons can be verified with total certainty, but it is not necessary that verification be perfect. The degree of verification required depends upon the judgments made by the participants concerning the benefits and risks involved in entering into an agreement. A country's perception of the delicacy of the strategic balance is clearly involved in such a judgment, as are the strategic consequences should cheating occur. The higher the perceived risks to the country if the other side should cheat, the higher must be the confidence in the verification procedure and the fewer the arms limitations a country is likely to accept in a treaty. Even a low probability of detection could be enough to deter violations if the benefits of the agreement are valued by the participants. A low probability of observing a single event rapidly becomes a much higher probability for observing at least one in a number of such events. For a serious violation, it would be necessary in most cases to introduce many weapons to upset the military balance. It is only when armaments are reduced to very low levels that introduction of a small number of powerful weapons could significantly alter the military balance.

Attitudes toward the means used for verification will vary; this is especially true in the case of inspection. In an open society, so much is published that little will be gained by inspection. In a closed society, secrecy itself may be considered a military asset. Clearly, evasion would be much easier to arrange in a closed society than in an open society. Thus, agreements that included close inspection would generally be favored by an open society and disfavored by a closed society.

In lieu of on-site inspection, verification can rely on national technical means, which are those techniques a nation has under its control to monitor the compliance with the provisions of an agreement. In this case, verification depends to a considerable extent on the sophisticated techniques of intelligence collection, but there are important differences in the objectives of verification and intelligence. While arms-related intelligence seeks to determine the number, characteristics, and activities of an opponent's military force, verification attempts to prove a negative: that certain force levels are not being exceeded or that certain activities are not taking place.

The difficulty of this task creates some level of uncertainty in the verification process which must be dealt with by setting standards of verification confidence. If confidence standards for detection of violations are set too low, violations may be invited and the constraints set by the agreement may become a liability for the side that observes them. If confidence standards for detection of violations are set too high, however, agreement may be impossible and the benefits of the agreement may be lost.

To date, verification has played a key role in arms control efforts. The 1972 Treaty on the Limitation of Antiballistic Missile (ABM) Systems and the SALT I Interim Agreement were largely shaped by verification considerations. In the MFR negotiations, verification problems are critical, particularly in the case of potential agreements that envisage small initial reductions in the number of troops and equipment. There is no reason to expect that verification will be any less critical in future agreements, but there have been developments which lead one to believe that adequate verification will be more difficult in the future.

One reason verification will be more difficult in the future is that the rapid development of new technologies is shifting the focus of arms control from quantitative to qualitative aspects. Therefore, much will depend on the ability of the participants to monitor controls on technological improvements in weaponry. Marked improvement in verification techniques may be needed to verify agreements concerning multiple independently targetable reentry vehicles (MIRV's), cruise and ballistic missiles (problems of range and launch platforms), and bombers (problems with variants, range, refueling tankers, and air-to-surface missiles). These difficulties will be in addition to the problems associated with keeping track of mobile ICBM systems and with the development of "cold launch" techniques for silo-based missiles which could enable a single silo to launch several missiles in a short period of time.

Another reason verification will be more difficult in the future is that the small size and high mobility of new weapon systems, as well as the diversity of platforms available for their launch, will severely test the effectiveness of unobtrusive methods of monitoring compliance. The cruise missile highlights these new challenges. There are substantial difficulties, if not impossibilities, in accomplishing the following by nonintrusive means: (1)

determining the number of cruise missiles deployed, since they do not require identifiable launch facilities; (2) determining the maximum range of a particular cruise missile or whether its mission is tactical or strategic; or (3) distinguishing between nuclear and nonnuclear cruise missiles. With cruise missiles the launcher-missile equation breaks down altogether; not only can a single aircraft, submarine, or surface platform carry and launch several missiles, but the missiles can be accommodated aboard a wide range of aircraft, naval vessels, and land launchers.¹³

As a result of the technological developments, there is a growing effectiveness of satellite reconnaissance and other unobtrusive means of gathering intelligence for verification purposes. The United States, and presumably the Soviet Union, will have more frequent and more reliable surveillance, both electronic and photographic. Both sides will be able to make better use of specialized surveillance such as infrared photography and radar. In many cases, the combination of methods available will greatly increase both sides' ability to identify and understand certain activities.

At the same time, improved technology will make it easier to avoid surveillance by national technical means. Electronic miniaturization and dramatic reductions in the cost of small computers will make it possible to encrypt, unless prohibited by agreement, almost all electronic signals. With time, activities can be shielded from photographic observations, although this is not as easy as is often assumed, given the size of the projects and systems involved. Finally, as both sides gain experience with surveillance systems, it may become easier to decoy and spoof them. Thus, which of the two types of technological improvement, better surveillance or improved countermeasures, will win out is not yet clear.¹⁴ Of course, countermeasures can be prohibited by agreement, but the safeguards against cheating on such agreements are limited. Deliberate concealment measures were prohibited by the SALT I agreements and most likely, together with encryption of test signal, will be prohibited in any SALT II agreements which are reached.

Arms Control Agreements May Be Unilaterally Terminated

Arms control agreements may be unilaterally terminated at any time by any participant. No nation will comply with the terms

of an existing arms control agreement if it concludes that conformity to the terms of the agreement has ceased to be in its national interest. This fact has been recognized in the ABM Treaty and the Interim Agreement by a provision which allows a nation to withdraw after certain notification procedures are fulfilled. Of course, it is possible that a nation may withdraw from the agreement without complying with the notification procedures. In this case, the first evidence of the intentions of the defaulting party may be the detection of the violation of the agreement. Historically, open violations of arms control agreements have occurred more often than clandestine violations.¹⁵

A party to an arms control agreement must be constantly concerned about its ability to recognize that another party is violating the terms of the agreement. It is important to determine if the violation is (1) local in character and the result of an accidental oversight or unauthorized action; (2) limited but the result of a conscious attempt to stretch or test the bounds of the agreement; or (3) massive and intended to achieve a significant military or political advantage. The intent of the violator (to the extent it can be determined), the nature of the violation, and the impact of the violation on the relative balance will determine the response to be taken. It should be noted that cheating is more profitable at lower levels than at higher levels of strategic arms because it is easier to rapidly alter the ratios of power in being and achieve the capability to destroy a substantial portion of an adversary's forces.

The uncertainty of whether the other party will continue to abide by the agreement for its duration compounds the already existing uncertainty of technology and the long lead times associated with developing and deploying a new offensive or defensive capability. In the face of this uncertainty, a nation must decide what is the prudent policy to be followed in the area of technology. On the one hand, the nation does not want its security to be put in jeopardy if the other party withdraws from the existing agreement. On the other hand, the nation does not want to take actions which might foreclose future arms control agreements if the other party continues to abide by the agreement.

To guard against an opponent securing a military advantage, a nation will wish to know what options are available and which of these other nations are pursuing. The first need can be satisfied to some extent by a broadly based technology program. Hence, the

great powers consider it essential to maintain a military technology capability not only in order to modernize their own forces but also to estimate possible improvements in those of the opponent. For this reason, as well as others to be discussed later, arms control agreements are unlikely to be reached that attempt to restrict technology. However, there may be instances where, because of special circumstances, this general statement does not apply. For example, the number of missile flight tests may be restricted to limit the rate at which incremental accuracy improvements can be made, or the type of tests may be restricted to prevent the development of a reliable maneuvering reentry vehicle MaRV which might reduce the miss distance to essentially zero.

Unpredictability of Future Arms Control Agreements

The content and time frame of future arms control agreements are unpredictable. At the start of negotiations there is a reasonable amount of uncertainty as to what categories of arms will be covered by the agreement. There is also uncertainty about the effective date and duration of the agreement. Once an agreement is reached, there is uncertainty with respect to whether the limitations of the existing agreement will be incorporated in a follow-on agreement and if so, for how long. All of these uncertainties were evident in the negotiations leading to the Interim Agreement (signed in 1972), in the agreement itself, and in the negotiations on a follow-on agreement. The content and duration of the agreement were uncertain almost to the day it was signed. No subsequent agreement was arrived at prior to its expiration in October 1977, although both parties made unilateral declarations that they would continue to observe the agreement while negotiations continued on a follow-on agreement. The content and time frame of the follow-on agreement remain unresolved and it is possible that no agreement will be reached or that, if reached, it will be rejected by the Senate.

Given this uncertainty, what is a prudent technology program? The short-term implications of this uncertainty are the least difficult to handle since the policymaker knows the range of the possible agreements and can take actions to protect his options outside of the range of possible agreements. Unfortunately, in terms of an arms control negotiation which lasts 5 years, it is hard to define short term. Would it have made sense for the United States to stop deploying MIRV's or developing cruise missiles in

1972 in anticipation of arriving at a future agreement on these systems? Would the Soviets have been willing to do the same? If so, would we have been able to adequately verify that they were doing so?

As to the long term, clearly we cannot predict the status of arms control negotiations 10 years in the future or what systems will be subject to negotiations, if any. The cruise missile, for example, has been in the Soviet inventory and in US development for years, but did not become an arms control issue until recently. Can the R&D decisionmakers of the early 1970's be faulted for failing to realize fully the arms control implications of the system? And even if they did realize these implications, what should they have done about the cruise missile?¹⁶

Because of the unpredictability of arms control agreements, a nation must take those actions necessary to guard against an opponent securing a significant military advantage. These actions are essentially the same as those a nation must take to protect itself from a unilateral withdrawal from an existing arms control agreement. The actions were discussed in the preceding section.

Arms Control Agreements Involve Lengthy Negotiations

Arms control agreements are arrived at through a lengthy negotiation process. The SALT I negotiations lasted for nearly 3 years and were only concluded at the last minute at the Nixon-Brezhnev Summit in May 1972. SALT II negotiations have been underway for nearly 5 years. The MFR negotiations have been ongoing for 5 years with an agreement seemingly still a distant goal. The period of negotiations, historically, has been of the same order of magnitude as the time required to develop a new weapon system or to make major improvements in existing weapon systems.

Because of the lengthy negotiation process, by the time a weapon system is limited via an arms control agreement, there is a high probability that it has already been modified in a substantial way or become obsolete. This can have the effect of seriously decreasing the impact of arms control agreements. For example, the value of the limit on the number of launchers, as is contained in the Interim Agreement, is decreased when the missiles can be MIRVed, thus increasing the number of warheads by an order of magnitude. Likewise, the arms control value of restrictions on the number of long-range bombers would be decreased if the bomber's capability can be significantly increased by the addition of a large number of cruise missiles.

During the lengthy negotiations process, technological change tends to alter the important variables in the arms control equation which may neutralize the effect of the negotiated limits. Because of technological change arms control tends to fall behind during these lengthy negotiation periods, and hence, arms control is often in the position of attempting to catch up with the latest changes in weapon system capabilities. This happened with respect to MIRV's in SALT I.

Arms Control Agreements Must Consider Allies' Interests

Arms control agreements which affect the interests of others take into account these interests and take a form which is generally acceptable to the allies. Arms control agreements have implications for international politics beyond the relationship between the superpowers. The relationships within alliances and the extent to which the nuclear deterrence of one power can be extended to protect another must be considered. Negotiations and agreements that are stabilizing for the superpowers may be destabilizing for allies. The net affect of these considerations is that no member of a freely formed military alliance, who values the continuation of the alliance, can with impunity take independent arms control actions which are not generally acceptable to its allies. This view has been substantiated by US consultations with NATO and, to a lesser extent, Japan during SALT I and II.

The quest of the superpowers for strategic stability between themselves has implications for relations between superpowers and their allies. The quest is potentially counterproductive if the superpowers do not take sufficient account of the interests of their allies. For example, an arms control agreement may limit the capacity of a superpower to maintain a credible link between the strategic deterrent and the defense of its allies. Ratification, through an arms control agreement, of a form of equivalence between the United States and the Soviet Union may serve to reduce the linkage between the US strategic deterrent and the defense of Western Europe and Japan, although the extent of such reduction will depend on the kind of agreement that emerges from the arms control negotiations. So long as NATO lacks the capability to offset the Soviet M/IRBM force, it appears that any agreement which has as its basis equivalence in strategic weapons may work to the Soviet advantage.¹⁷

The problems created for allies by arms control negotiations are highlighted by the dilemma facing NATO as a result of US-Soviet discussions in SALT II of limitations on cruise missiles. The members of NATO want a voice in the preparation of positions on the cruise missile, but they are afraid of pushing Europe out from under the protective American nuclear umbrella. In other words, they do not want the United States to bargain away weapons of the future with which they can defend themselves, nor do they want to provoke ideas of an independent European nuclear force. In the final analysis, the extent to which US allies can influence the outcome of arms control negotiations on the cruise missile, or any other area of concern to them, is a function of how far they are willing to carry their objections to specific arms control provisions and the value that they and the United States place on the alliance and harmony within the alliance.

Arms Control Agreements Consider Other Rivals

Arms control agreements take into account existing or potential rivals of the participants and must not jeopardize the security of the participants vis-a-vis the rivals. The concept of strategic arms control was born in the conditions of a bipolar world tailored to negotiations in a military environment dominated by the United States and the Soviet Union. This concept will have to be modified should the strategic capabilities of other nations, such as the PRC, increase to levels which could inflict significant losses on the United States or the Soviet Union. This will occur more rapidly if the superpowers substantially reduce their arms as a result of arms control.

At the present, because of the large gap in the strategic arms capabilities between the superpowers and the other nuclear powers, the superpowers can, for arms control purposes, almost ignore the capabilities of the other powers as they negotiate agreements. However, it is likely only a matter of time until the superpowers will have to face the problem of nuclear arms control in a multipolar world. The multiparty arms control negotiations will be much more difficult because of the increased number of asymmetries which will be involved. The task of solving the current problem associated with the asymmetries between the superpowers foreshadows the difficulties in strategic arms control negotiations within the emerging multipolar world.

We can anticipate that in the next decade the nuclear capability of the PRC will be greatly strengthened. It is unlikely that the PRC will negotiate an arms control agreement which would allow itself strategic forces that are less than equivalent to those of the United States and the Soviet Union. On the other hand, if the PRC refuses to be party to an arms control agreement, it appears that the level of strategic forces maintained by the PRC will determine the lower limit of what is possible in a bilateral US-Soviet agreement since neither is likely to be willing to be inferior in strategic forces to the PRC. The emergence of additional nuclear power centers will further increase the complexity of arms control negotiations and will make even more difficult the development of agreements because of the additional interests that must be satisfied.

TECHNOLOGY

Technology plays a major role in shaping the environment in which arms control is pursued. The evolution of technology has the following characteristics which impact on the arms control process:

1. The rapid growth in technology is resulting in new military capabilities at an accelerating rate. These new capabilities can increase or decrease strategic stability.
2. The new military capabilities which result from the rapid growth in technology are highly unpredictable in form, characteristics, and time.
3. There is a significant overlap between civilian and military technology. A technological breakthrough which results in a new military capability may be developed in either sector and may have applications to one or both sectors.
4. The development of new technologies with military applications is significantly decoupled from the operational need for a specified military capability.
5. Technological information of significant military value is protected from disclosure.
6. There are significant asymmetries in the technology bases of the United States and the Soviet Union.

The following section examines these characteristics of technology as they relate to arms control.

Rapid Growth In Technology

The rapid growth in technology is resulting in new military capabilities at an accelerating rate. At no time in man's history have the affairs between nations been so heavily influenced, if not guided, by a rapid growth in military technology as in the years since the end of World War II. Technology which was considered remote or even unachievable only 10 years ago has, in fact, been realized and startling breakthroughs are now taken for granted. An analysis of the scientific effort of the world clearly shows that a rapid, indeed exponential, growth in technology has occurred. In his book, *Science Since Babylon*, Price persuasively argues that the growth in science is a true exponential, only displaced twice by the consequences of the great wars.¹⁸ While Price's analysis is related to the growth of science, not technology, there have been sufficient analyses of the direct flow of ideas from science into technology to make evident the close connection between the two.¹⁹

This great growth has called for trained people, especially scientists, engineers, technology-oriented managers, and technicians. Such people have been educated and trained in sharply increasing numbers. This growth of science and technology, and of numbers of scientists and engineers, has been paralleled by the growth of a set of industries skilled in the sophisticated application of technology. The most significant characteristic of this industry in the United States is its steadily increasing skill in converting basic and applied science into usable technology.²⁰

This rapid growth in technology produces new military capabilities as a result of applying new scientific principles. This approach has produced radically different capabilities such as nuclear weapons and high energy lasers. New military capabilities also result from novel extrapolation and assembly of familiar scientific and technological principles and devices. In this case, a number of independent and quite disparate lines of research may be brought together to create a new capability for existing weapons or even new weapons. Precision-guided munitions (including cruise missiles) and remote pilotless vehicles are examples of this process.

The rapid growth in technology essentially insures that new capabilities or improvements to existing capabilities will be continuously developed which will affect the relative balance of

forces. In addition, by injecting new uncertainties into the future shape and effectiveness of military forces, the rapid growth in technology will make nations hesitate to accept arms control limits on new, but untested options and make them reluctant to enter long-term arms control arrangements whose military implications could change over time. This attitude was evident in SALT I in the unwillingness of the parties to agree to any limitations on MIRV's.

Technological developments result in new capabilities which have stabilizing or destabilizing effects when considered from an arms control viewpoint. The following are some of the *stabilizing* capabilities which have resulted from technological developments:

- Reduced vulnerability of deterrent forces to surprise attack. The nuclear-powered submarine, submarine-launched ballistic missiles, hardened silos, and quick-start engines for bombers and tankers are examples.
- Safeguards against accidental launch.
- Increased reliability of warning and of command and control.
- Improved intelligence collection means.
- Improved national means of verification.
- Weapons with reduced collateral damage.

Technological developments can also result in capabilities which have *destabilizing* effects, such as:

- Weapon systems with characteristics which increase the likelihood that they will be used in a first strike or which increase the vulnerability of other weapon systems. Highly accurate land-based ICBM's, depressed trajectory modes for SLBM's, and developments in undersea surveillance are examples.
- Weapon systems whose numbers and characteristics (such as range, mission, payload, launcher, and deployment) cannot be effectively verified by national means. The cruise missile is an example.
- Capabilities which tend to require offsetting technological or force developments. For example, ABM's were an important impetus for MIRV's and MaRV's.

- Capabilities making it easier to avoid surveillance by national technical means. For example, electronic miniaturization and dramatic reductions in the cost of small computers will make it possible to encrypt almost all electronic signals.
- Capabilities to interfere with warning and surveillance systems. Anti-satellite systems are an example.

The military capabilities which result from the new technology are typically more sophisticated and complex technically and more effective and versatile militarily. These characteristics are evident in systems such as MIRV's, precision-guided missiles (including cruise missiles), remotely piloted vehicles, and laser beam weapons. These characteristics make these systems more difficult to define and constrain by new arms control agreements. Consider the difficulty of drafting verifiable treaty provisions to constrain small, highly mobile cruise missiles which can be launched from ground, sea, or air platforms at tactical or strategic targets with either nuclear or conventional warheads.

The rapid growth in technology both contributes to and detracts from the fragile stability that exists in the world. The rapidity of the evolution of new military capabilities, as well as the number of new capabilities, threatens to overwhelm the faltering steps the superpowers have taken in controlling arms.

Unpredictability of Technological Developments

The new military capabilities which result from the rapid growth in technology are highly unpredictable in form, characteristics, and time. Recent history provides us with several examples of this unpredictability. A 1937 study entitled "Technological Trends and National Policy" failed to foresee the following systems: helicopters, jet engines, radar, inertial navigation, electronic computers, nuclear weapons, rocket-powered missiles, cruise missiles, recoilless rifles, nuclear-powered ships, and satellites. All of these systems were operational by 1957 or earlier. The 1945 Von Karmann Study, "Toward New Horizons," failed to foresee man in space, solid-state electronics, and ICBM's, all of which were operational within 15 years. In 1966 the *Wall Street Journal* had a series of articles on life in the year 2000 which explored, among other things, the nature of war at the turn of the next century. The military experts whom it consulted failed to foresee the rapid

emergence of the automated battlefield, including precision-guided weapons and remote electronic sensors which are already a reality.²¹

These unpredicted new capabilities were made possible by numerous technological developments including new alloys and fabrication techniques, solid state devices, and microelectronics. Each of these technological developments had more than one effect. The most important effects were often indirect, and may not even have emerged until further technology was developed. This is true in the case of the cruise missile, an old weapon, which has taken on a strategic role as the result of new guidance techniques and advances in engine technology.

Ideally, technological developments which produce new military capabilities with undesirable characteristics should be limited or controlled, while technological change which renders forces more stable and less destructive should not be restricted. Unfortunately, whether technological developments are desirable or undesirable from an arms control point of view is impossible to forecast because they may become critical elements in both desirable and undesirable new capabilities. They may also be key elements in desirable civilian equipment while simultaneously being key elements in undesirable new military capabilities.

In actual practice, it is even difficult to distinguish between desirable and undesirable new military capabilities. The development of nuclear-powered submarines and improved means of verification are today viewed as two of the most notable improvements in military technology in the past 20 years. The first has made possible significant reductions in the vulnerability of strategic forces and thus made surprise attack less likely. The second has reduced uncertainty in arms competition and also made possible progress in arms control. Today no one would question the value of these new technologies. Yet, at the outset, their impact was much less clear. Not only were there serious doubts about technical feasibility and cost effectiveness, but there were grounds for concern that other countries might view such developments as provocative, as efforts to achieve a unilateral US advantage, or to improve our capability to launch a surprise attack.²²

In the face of the unpredictability of technological development, a nation is confronted with the problem of developing, producing, and deploying weapon systems essential to

a credible military posture. The long lead times, on the order of 5 to 10 years, required to field new weapon systems add to the uncertainty. Given all the uncertainty involved it is no wonder that a nation seeks to protect its options and to prevent surprise through a vigorous R&D program. Given the dynamics of technology, the vigorous R&D program further complicates the arms control process.

Civilian-Military Technology Overlap

*There is a significant overlap between civilian and military technology. A technological breakthrough which results in a new military capability may be developed in either sector and may have applications to one or both sectors. In the United States, in particular, much of the development effort that leads to new military technology is an outgrowth of, or is done in parallel with, development efforts for new civilian technology. Indeed, in many technical areas, such as computers and microprocessors, the efforts directed toward military and civilian technology are quite indistinguishable.*²³

Likewise, it is also true that military and civilian technology ultimately stem from the same basic and applied research. This results from the open nature of Western society, the integration of basic and applied research in the US corporations, and the mix of civilian and defense business of US corporations. For example, transistors and other solid-state devices have essentially replaced vacuum tubes in both military and civilian systems. Similarly, the production of sophisticated military equipment involves the same kind of production-line facilities, specialized equipment, and skilled workers and managers that similar civilian technology involves.²⁴

This same relationship of civilian to military technology exists throughout the free world. While the exact nature of the relation in the Soviet Union and the PRC is not known, it is evident that there is some relation, albeit perhaps a weak one, between the civilian and military technology in these closed societies.

Clearly, at least within the United States, military technology is imbedded in and derivative of civilian technology. This fact becomes relevant in the arms control context when the question arises as to whether or not it is possible and feasible to put restrictions on technological activities in order to prohibit possible expansion of arms competition into new areas. The central

difficulty is, of course, that the same technology can serve the purposes of both peace and war. The same microprocessor can be used in a cruise missile as is used in the navigation equipment of a commercial airliner. The same microbiological research which promotes public health can contribute to the development of biological warfare or the protection against such warfare.

This problem is further complicated by the fact that it is impossible to predict in advance where a military application would arise. A discovery in one area might have an entirely unexpected application in another area. In fact, many of the more valuable results of R&D efforts turn out to be externalities or spin-off benefits. Thus, it seems that unless a society is willing to forego all advances in technology, it is impossible to prevent generation of technology with undesirable arms control implications.

The fact that it is impossible to control the development of new technologies which, if exploited, would result in meaningful new military capabilities, does not mean that it is necessarily impossible to control the exploitation. The parties may agree to:

- not deploy a system which incorporates a given technological capability. This was done in the case of the antiballistic missile system.
- limit the numbers of systems deployed which incorporate a given technological capability. This has been done in the case of ICBM's and is possible for MIRVed systems and aircraft.
- slow down the rate at which technology is exploited. This could be done by limiting testing which would limit the confidence which could be achieved concerning the effectiveness of the new capability.

While agreements like those discussed above control to some extent the use of new technologies, state-of-the-art improvements will undoubtedly be incorporated in follow-on systems because of the continued incorporation of the latest technology in the defense industry. The almost inevitable result of the incorporation of the state-of-the-art is increased reliability, accuracy, controllability, and range, and decreased size and weight, all of which have arms control implications. State-of-the-art improvements will undoubtedly be more difficult to control than the deployment of new weapon systems.

In summary, the overlap of civilian and military technology makes it impossible to place general controls on the development of technology in order to prevent the development of new weapon systems. This still leaves open the possibility that agreements may be negotiated which limit the exploitation of some technological developments. The ultimate utility of these agreements would to a large degree depend upon the ability to adequately verify that the other side is complying with the terms of the agreement. That this can be accomplished to the degree necessary may be the fundamental limitation on such agreements.

Technology Decoupled from Military Requirements

The development of new technologies with military applications is significantly decoupled from the operational need for a specified military capability. The development and production of modern military equipment is an extremely complex task requiring skilled, specialized resources. To meet this need the United States, the Soviet Union, and most other developed nations have an establishment of committed laboratories, trained engineers, and large industries, all specializing in the production of military technology. These technical and industrial teams are regarded as national assets which, given the dynamics of the technological process, cannot be allowed to disintegrate without risk to the nation's ability to keep abreast of foreign developments in weapons technology. It is assumed, with considerable historical justification, that the enemy is likely to discover new weapons or techniques and that the only safe way is to push ahead. In other words, these resources must be kept fully employed at all times, and this automatically leads to the continual development of new weapon systems.²⁵

Less and less today do these teams respond to a perceived need based on a specified operational requirement. This is caused in a large part by the fact that lead times have been extended to the point where it takes 5 to 10 years to get a weapon from R&D into inventory. This has necessitated extensive changes in the procurement process. Technological development to a large extent has been decoupled from immediate operational needs and a separate technical war arena has thus been created. As a result weapon system requirements are often not defined in terms of what is needed but rather in terms of what is possible. The basic question is: "What can you possibly give me in 10 years?" rather

than "What can you give me now to do a certain job?" The new capability is subsequently "sold" to the military establishment as a desirable capability. In other words, the new capability is a solution looking for a problem, or in military terms a new offensive capability looking for a mission or a new defensive capability looking for a threat.²⁶

The net result is that the scientists and engineers will produce a new generation of weapons, regardless of their contemporary arms race relevance, simply because it is their task and because the frontiers of knowledge beckon the inquisitive. Whatever is technically possible must be developed. The motivation seems to be to fully exploit available technological opportunities. Hence, in the absence of some constraint, the technology process becomes an ungovernable and self-propagating process. It does not need an increase in international tension and hardly a real enemy to keep going.²⁷

This momentum of technology can exert a very real set of pressures. It appears that President Eisenhower had pressures of this kind in mind in his famous 1961 warning against the "military-industrial complex." In talking about these same pressures Secretary McNamara said, "There is a kind of mad momentum intrinsic to the development of all new nuclear weaponry. If a weapon works—and works well—there is a strong pressure from many directions to procure and deploy the weapon out of all proportions of the level required."²⁸ These pressures are bureaucratic, economic, and political. They are bureaucratic because the large technology-oriented defense establishments cannot fail to generate persuasive proposals for new weapon systems or for improvements to older ones. They are economic and political because the large development and production efforts of major defense-oriented industries have become important and accepted means of livelihoods in many communities. The maintenance of a high level of employment in these communities is a matter of direct concern to the congressional representatives of these communities.²⁹ Perhaps, the various pressures would not be nearly so compelling if there were not a widely shared view in the United States that there are valid military reasons for maintaining a substantial defense capability in light of Soviet ideology and military capabilities.

Protection of Technological Information

Technological information of significant military value is protected from disclosure. All countries have laws designed to protect technological information of military value. The effectiveness of these laws depends to a great extent on the nature of the society in which they operate. In an open society such as the United States, they are relatively ineffective while in a closed society such as the Soviet Union they are the most effective.

In the United States, plans to develop, deploy, or modify a weapon system are likely to become public knowledge very quickly. On the other hand, the Soviet Union can go a long way in secrecy. As Dr. John Foster pointed out when he was the Director of Research and Engineering in the Department of Defense:

Because of Soviet secrecy, by the time we have firm evidence of precisely what the Soviets are doing, their development has been underway for several years. Even then we often have difficulty in understanding their new system capability. If we react only when we know precisely what they are doing and why, we generally require about four years for development and another three to four years to fully deploy a countermeasure.³⁰

Thus, if the United States reacts only when it knows what the Soviets are doing, it is several years behind. On the other hand, if the United States chooses not to be in a reaction mode, the long lead time necessary for deploying a new weapon requires the United States to plan for a time so distant that the Soviets themselves may not yet know what their forces will look like and if they do, they could revise their plans between now and then.³¹

This uncertainty as to the development activities of the other side causes each side to react, to hedge against uncertainty, and to protect its options. Dr. Foster believed that the only way the United States could guard against Soviet secrecy and unilateral exploitation of a technological breakthrough was by maintaining an extensive R&D program designed to hedge against this possibility. From this point of view, control of the dynamics of the technological process may be beyond the capacity of either superpower under the present conditions.³²

The arms control implications of this lack of control are far ranging. New weapon systems will continue to be developed with

little hope that the process will ever be controlled. Under these conditions, the challenge for arms control will be to deal with the weapon systems which are the output of the uncontrolled process.

Asymmetries In Technological Bases

There are significant asymmetries in the technological bases of the United States and Soviet Union. While education and science policies affect a nation's technological base, the structure of a nation's industry plays a key role in determining its technological base. Given the impact of a nation's political and economic systems upon the structure of its industry, it is not surprising that there are significant asymmetries in the technological bases of the United States and the Soviet Union.

Soviet industry is relatively efficient in the development of mass produced systems, and relatively inefficient in the production of more complex, high technology weapons. There is general agreement among analysts of both the Soviet Union and non-Soviet countries that in no major branch of industry is the average level of Soviet technology in use even close to equality with that of the United States and Western Europe. Recent analysis reveals similar patterns in weapons. This state of affairs is, at least in part, the result of a centrally administered economy that has no automatic mechanism for fostering technological progress. New products and production techniques must be planned deliberately and introduced by administrative bodies and central government commissions.³³

The strength of US military development lies in the technical competence, productive capacity, and innovative nature of US industry. In addition to the industrial giants, there are thousands of small firms and semiautonomous corporate divisions that support the larger establishments. These are the organizations that are missing in the Soviet Union. They provide alternative sources of supply of old and new products, and they can respond to the shifting demands of R&D in ways that are not possible for centrally planned ministries. It is this capacity of American science and industry that has fortified the American military's belief in the value of quality over quantity.³⁴

While it is generally accepted that the United States has an overall stronger technological base, the Soviet Union has the lead

in several significant areas. Dr. Malcolm Currie stated, when he was the Director of Research and Engineering in the Department of Defense, that the Soviet Union led the United States in high-pressure physics, welding, titanium fabrication, high frequency radio-wave propagation, magnetohydrodynamics, power generation, antiship missiles, chemical warfare, and artillery technology. He also indicated that the United States had a substantial lead in integrated circuit fabrication, computers, high bypass ratio turbofans, air-to-air missiles, numerically controlled machine tools, avionics, composite materials, inertial instrumentation, precision-guided weapons, and satellite-borne sensor technology.³⁵

These differences in the technological bases of the United States and Soviet Union result in different weapon systems or similar weapon systems possessing different capabilities. For example, both sides are modernizing their ICBM forces, but in the US case, the emphasis is placed on improving existing systems, with emphasis on their accuracy, while the Soviet Union has chosen to deploy a new generation of missiles, with not only greater accuracy but also higher payloads. The United States is stressing cruise missiles and considering mobile ICBM's while the Soviets are developing a new generation of fixed land-based ICBM's and a mobile IRBM system.

As the strategic forces of the opposing sides continue to diverge, arms control agreements will increasingly appear to be comparing "apples and oranges." The units of comparison (number of launchers or platforms, number of reentry vehicles, payload, yield, etc.) will become increasingly more difficult to agree upon. While this problem may not be insurmountable when the number of deployed systems is high and there is excess capability, it will become increasingly more important and more difficult to resolve if the number of deployed weapon systems is reduced significantly.

To the extent that the asymmetries in the technological bases cause the weapon programs of the parties to be out of phase, they create obstacles to arms control agreements by complicating the timing of any negotiation. For example, when President Johnson proposed strategic arms limitation talks to Premier Kosygin in January 1967, the United States was well ahead. By then, most of its strategic forces were operational. The Soviet Union was in quite a different stage with its massive buildup beginning only in 1965-1966. It was not until June of 1968, when

the first major steps in the Soviet buildup were nearly complete, that Foreign Minister Gromyko indicated that the Soviet Union was willing to start such talks.³⁶

CONCLUSIONS AND IMPLICATIONS FOR FUTURE R&D AND ARMS CONTROL EFFORTS

From the discussion of the nature of arms control and technology, it is possible to draw conclusions which relate to their interaction. These conclusions are statements of the realities that constrain what is possible in arms control or technology.

With the exception of certain limits on testing which may inhibit the rate of technological development, it is not possible to reach arms control agreements which place controls on R&D activities which could lead to the development of militarily significant technology because:

- Civilian and military technology overlap, making controls on all relevant technologies unacceptable within the US political and economic systems.
- It is not possible to determine in advance whether certain R&D activities will result in technology which contributes to desirable or undesirable new military capabilities.

In the present competitive environment, it is undesirable to place unilateral controls on R&D activities which could lead to the development of militarily significant technology because:

- A high level of technology is essential to evaluating the efforts of adversaries and to developing countermeasures.
- It is essential that the United States have a broad technological base with which to deter and from which to react to a unilateral withdrawal from an arms control agreement or failure to reach a follow-on agreement.
- It is essential that the United States have a technological base to keep its options open until an arms control agreement is negotiated.
- A high level of technology is necessary to develop improved means of verification which will enhance the prospects of arms control.

Arms control is a major objective of US national security policy and is greatly affected by technological developments. Therefore,

military R&D policies and programs must support this objective. To do so R&D policies and programs must be directed toward certain objectives:

- R&D policies and programs must insure that no adversary gains a significant advantage by unilaterally withdrawing from an arms control agreement or failing to reach a follow-on agreement. This requires that the United States be prepared to rapidly deploy or counter a system which has been banned or limited by an agreement if its deployment is considered essential to US security. For example, the United States should be prepared to deploy an effective ABM system or an effective ABM counter if the Soviets were to abrogate the current ABM treaty.
- An adequate R&D base must be maintained to assess the implications of Soviet developments and to develop countermeasures if required.
- R&D policies and programs must provide for continued refinement of national technical means of verification which will provide the basis for future agreements and will detect violations of existing agreements.
- R&D policies and programs must provide for continued refinements of methods for avoiding accidents or the failure of control.
- R&D policies and programs must facilitate decisions on seeking arms control agreements which control the new military capabilities which result from technology. The R&D process must highlight early in the process the arms control implications of new military capabilities so that decisions can be made on whether or not efforts should be undertaken to negotiate controls on the new capability and, if so, when in the R&D cycle. These decisions must be consistent in the overall arms control negotiation strategy. Possible controls on new capabilities (either new weapon systems or improvements to existing weapon systems) include:
 1. Agreements to ban certain type tests. This would insure that particular weapons cannot be developed or cannot be developed to the point where they could be destabilizing.

2. Agreements to limit the rate at which new capabilities can be achieved. For example, limits on the number of ICBM flight tests to slow down the rate at which accuracy could be improved.
 3. Agreements to ban a system or to limit the number of systems deployed reached either before the building and testing of a prototype, or after the building and testing of a prototype, or after deployment.
 4. Agreements which prohibit the deployment of systems to certain areas; for example, space.
 5. Agreements which prohibit the deployment of systems based on certain physical principles, for example, particle beams.
- Finally, R&D policies and programs must emphasize the development of capabilities which provide for stability in the US-Soviet military relationship.

Arms control to date has tended to create equivalence in the number of systems possessing certain capabilities. Within the equivalence of numbers, the quality of the forces (reliability, alert rates, controllability, etc.) will be critical in determining the strategic balance. Superior quality can transform numerical equivalence into superiority in terms of deterrence or war-fighting capability. To insure that our strategic forces are not inferior to those of the Soviet Union, it is essential that US R&D policies and programs emphasize quality forces.

From the discussion of the nature of arms control and technology processes and from the conclusions concerning the interaction of arms control and technology, there appear to be certain steps which need to be taken to have coherent and compatible arms control and R&D policies.

At the highest level of the US Government, arms control and defense policies are integrated components of national security policy. These policies and the programs which support them need to be integrated at all levels. This requires a greater understanding of and an earlier involvement of arms control specialists in defense R&D matters and of R&D specialists in arms control planning. This integration should permit the development of broader congressional support for necessary R&D programs and arms control agreements.

Arms control undertakings and R&D programs must develop greater bipartisan support which will permit greater continuity from administration to administration. This will lessen the motivation of the Soviets to stall negotiations, as they did in SALT II, in the anticipation of reaching a more favorable agreement with the next administration.

Arms control planners together with defense planners must develop an overall comprehensive conceptual framework, including time phasing, for the negotiation of arms control agreements covering all significant existing and planned weapon systems which need to be controlled. This framework should make clear the forum (bilateral, multilateral, alliance to alliance, etc.) and the time frame in which each significant weapon system should be addressed. It should consider where the parties are now and where they are going in their weapon programs. At the appropriate time, relevant parts of the conceptual framework should be the subject of discussion with parties to future negotiations to gain their agreement on the approach. If arms control is to be successful, what must be created among the participants is, in effect, joint strategic programming. This framework should be updated as necessary to insure that it represents the real world to the extent it is known. Only by having developed a comprehensive conceptual framework can meaningful judgments be made on particular issues. This approach will, for example, force early consideration of the implications of any bilateral superpower cruise missile limitation on future negotiations between alliances and between the superpowers and the PRC.

Arms control planners, together with defense planners, must do an in-depth study of the asymmetries which must be dealt with in implementing the overall conceptual framework. This analysis will serve to refine the conceptual framework and help in the development of sound and consistent negotiating positions.

These conclusions and recommendations highlight the need for greater interaction and exchange of information between the defense community, especially R&D, and the arms control communities. This will only be possible in an environment of mutual trust and confidence. Thus far, this relationship has been, for the most part, distant and antagonistic with each seeking to achieve its objectives while seeking to limit the activities of the other. Each has sought allies to use in the fight against the other; the defense com-

munity has sought to ally itself with industry, certain congressional representatives, and elements of the press, while arms control advocates have aligned with academia, other congressional representatives, and other elements of the press.

One of the results of the inability of the arms control and defense communities to work together effectively has been the 1975 amendment to the Arms Control and Disarmament Act, which requires the executive branch to provide to Congress "a complete statement analyzing the impact" of certain R&D programs "on arms control and disarmament policy and negotiations" with requests for authorization or appropriation. There would be little or no requirement for such statements if the appropriate interaction had occurred between the arms control and defense communities as these new capabilities were developed.³⁷

Neither the arms control nor the defense community alone can provide adequate security for the Nation. Each group can limit the effectiveness of the actions of the other with the result that the security of the nation is endangered. Only by their working together can the Nation maximize its security.

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